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8 APR 1992

Final Report on AFOSR 89-0262, George J. Mpitsos, PI
Item 19 continued.

ABSTRACT

During this grant period we have conducted a series of computer simulation and physiological studies aimed at the goals of the proposed research.

Simulations: Processing of chaos and memory storage. In view of our previously published findings showing that motor patterns represent adaptive behaviors may be generated by chaotic activity, we have used computer simulations to examine the ability of simple networks to learn to process chaotic signals and to perform complex operations on them. These studies have shown that even simple networks can be used to understand how networks store information, much of which information can not have been obtained from the more complex biological systems. As one example, an important and unexpected finding is that networks having trainable thresholds, in addition to trainable synapses, can perform computations that trainable synapses alone can not, regardless of the number synapses that may be included in the network. Another finding is that when networks must learn several tasks simultaneously, the effective size of the network is self-limiting, and probably does not require special algorithmic rules for limiting the size of successfully computing neural connections.

Simulations: Time-Invariant Noise Algorithm (TINA). In another series of computer simulations we devised an algorithm to optimize network responses by adding constant levels of random noise to the learning rule at synapses and thresholds. The effect of noise on learned changes was controlled by the response of the system in a time-invariant process. TINA is better suited for use in adaptive systems than is simulated annealing (the typically used algorithm) because simulated annealing is time-dependent which makes it difficult to use in event-dependent situations.

Physiological studies: Visualization of ACh. *Major progress has been made in immunohistochemical studies of neurotransmitter and neuromodulator systems. In our previously funded AFOSR work, we showed that the cholinergic system is involved in learning in our experimental animal, the sea slug* ***Pleurobranchaea****. To find the cells involved in this process, we developed immunohistochemical methods for fluorescent visualization of acetylcholine (ACh) itself in nerves and nerve terminals. All antibodies and fixation methods were developed in our laboratory, and have been applied to both mammalian and invertebrate tissues.* **This a major AChievement, of interest to many people, and the first real success among many laboratories internationally that have long attempted to visualize ACh.**

Physiological studies: Convergence of neurotransmitter systems. One of our goals has been to understand what convergence and divergence mean in neural function, as already expressed in our previously funded AFOSR publications. During this past year we have also examined convergence and divergence among neurotransmitter systems, and examined (mostly through our own laboratory-developed antibodies) over a dozen transmitters, including GABA, ACh, DA, 5-HT, VIP, FMRF, SCPb, enchephalins, and histamine. In keeping with our electrophysiological work, these findings show that there is extensive divergence and convergence among these transmitters, and, quite likely, a deminution of explict projections to specific sensory/motor systems. That is, the findings indicate that function emerges dynamically, and probably variably, among all systems coactively rather than by selective activation of specific sensory or motor systems, or of a specific neurohumoral system.

Publications: The publications listed below are out or in press. Additionally, several papers are presently being written on the immunohistochemical work, especially on the localization and physiological verification of ACh both in invertebrate and mammalian tissues.

Annual Report on AFOSR 89-0262, George J. Mpitsos, PI
Item 19 continued.

PERSONNEL

1. George J. Mpitsos, PI: M. O. Hatfield Marine Science Center
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2. Seppo S. Soinila, Postdoctoral Fellow: M. O. Hatfield Marine Science Center
Newport, OR 97365. Has conducted the immunohistochemistry on neurotransmitters.

3. Robert M. Burton, Professor: Department of Mathematics, Oregon State University,
Corvallis, OR 97331. Collaborator in computer studies and nonlinear studies.

4. H. Clayton Creech, research assistant: M. O. Hatfield Marine Science Center
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PUBLICATIONS

Burton, RM, Mpitsos, GJ (1992) Event-dependent control of noise enhances learning in neural networks. Neural Networks. In Press.

Mpitsos, GJ (1992) Attractors Provide Mechanism for Gradient Descent in Biological Organization: Effect of Chaos and Noise. In *Behavioral Mechanisms In Evolutionary Ecology*, (L. Real, ed), pp In Press. Chicago: University of Chicago Press.

Mpitsos, GJ, Burton, RM (1992) Convergence and divergence in neural networks: Processing of chaos and biological analogy. Neural Networks In Press.

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Mpitsos, GJ (1992) Chaos in brain function. In *Neuroscience Year: Supplement 2 to the Encyclopedia of Neuroscience, Vol.* 2. (B. Smith, and G. Adelman, ed), pp 29-35. Boston: Birkhauser Boston.